BELLCOMM, INC.
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BSS 04069

SUBJECT: Modifications to the Apollo Lunar Surface Drill (ALSD) Case 340

DATE: April 17, 1969

FROM: P. J. Hickson

ABSTRACT

The present flight-qualified Apollo Lunar Surface Drill will enable the astronaut to emplace two ALSEP Heat Flow Experiment probes in the lunar sub-surface and collect a sub-surface core for return to earth. Because of the complexity and large number of operations required for the drilling task and the limitations of the present suit, the Astronaut Office has suggested that a much reduced task be designed for the first lunar drilling operation. The Martin/Denver proposal for design of the modified task is under review by MSC and early approval is expected. The possible degradation of the Heat Flow experiment as a result of the modified emplacement technique is examined and judged to be not significant. A formal review of the experiment feasiblity is therefore not required.

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MEMORANDUM FOR FILE

The battery-powered, fully-portable, flight-qualified Apollo Lunar Surface Drill (ALSD) will drill and core 2 holes 2.5 cm (1") diameter by 3 meters deep in a Surveyor lunar surface model. Drilling time is estimated at less than 1 hour, and the core from the second hole can be retained in capped sections of the titanium drill-string for return to earth. The two holes in the lunar surface will be sleeved with thin fiberglass casing to prevent cave-in, and the two ALSEP Heat Flow Experiment (HFE) probes will be deployed to the bottom of the holes. The drill string and hole casings are sectioned in 43 cm (17") lengths to fit the LM stowage and astronaut reach constraints. A foot-operated treadle and a hand-wrench are required to break the joints between sections. The astronaut drilling task was configured with continuous astronaut test-and-feedback and, while taxing and even challenging, the task is clearly feasible. It must be admitted that the task is not easy because of the sheer number of simple operations and the Limitations of the present suit.

The astronaut office has given clear indication that it will not commit to the ALSD drilling task, now scheduled for ALSEP III or Apollo 13, at this time. Therefore, major simplification and acceleration of the drilling task is required for at least the first HFE deployment. To do this, it has been decided to separate the HFE probe deployment and the core return-sample operations. A pre-proposal meeting on ALSD modification was held by MSC at Martin/Denver on March 20 and 21, 1969. As a result of the meeting, the Martin proposal to MSC contains the following two items:

1. HFE Deployment Task Modification

The fiberglass casing will be strengthened with boron filament and provided with a drill bit. Sinking this casing will then eliminate the entire coring operation and greatly simplify the HFE probe deployment. The lunar model used in drilling qualification tests is essentially unchanged, and the new casing must be capable of drilling through 25 cm (10") of 50% porosity vesicular basalt in 10 minutes.

2. Coring Modifications

a. The full coring capability of the present drill will be maintained (95% recovery of a 3 meter core, returned in a Sample Return Container). Martin proposes a short paper study to list the drilling time and effort as a function of core depth.

b. Martin proposes a drastically simplified coring task which will be assured of astronaut approval and acceptance. This task involves taking a 86 cm (34") long by 3.8 cm (1 1/2") diameter core including as much as 15 cm (6") of vesicular basalt. This task will not require a wrench or treadle, since the two drill sections will have quick-disconnect (loose) joints. The new design will be made of materials compatible with the very tight schedule (no titanium). The present drill head will be used.

The proposal has now been received at MSC, and a go-ahead is expected in April for flight deliveries in August.

Comment

1. The HFE Principal Investigator (M. Langseth, Lamont-Doherty Geological Observatory) has made preliminary estimates of the probability of encountering a rock of thickness greater than a given number. These estimates use the Surveyor areal density data converted to volumetric densities. These estimates indicate a 90% probability of encountering a 25 cm (10") thick rock when drilling a 3 meter hole and a 70% change of encountering a 5 cm (2") thick rock while drilling a 1 meter hole. The rock drilling capability of the hole casing was therefore set at 25 cm (10"), but the coring drill-string capability was taken as 15 cm (6") of rock to ensure the capability of getting a sample of "basement rock". Rock is taken to mean 50% vesicular basalt. These estimates seem reasonable but are not unduly conservative.

2. The drill modifications have not resulted in any degraded or altered model of the lunar surface. The heat flow measurement will be degraded, however, because of the following:

a. the shorting effect of the higher conductivity casing will degrade the gradient measurement slightly (corrections for shorting are larger and more complex.

b. the thermal conductivity measurement will be degraded because:

1. the HFE will be deployed in a debris layer, a manifestly disturbed and non-homogeneous region, which is therefore, not ideal for a moon-representative measurement.

2. the casing will compact (disturb) the lunar soil due to the lack of a coring device.

3. the absence of a returned core may reduce confidence in the in-situ measurements and will reduce confidence in any hypothesized sub-surface stratigraphy.

4. the higher conductivity casing between the heaters and the moon will increase the k-measurement errors by as much as a factor of 2 and may reduce somewhat the range of k values measureable.

In my judgement, the HFE still retains adequate redundancy (2 holes, at least 4 gradient measurements, 8 k-measurements, at least 4 diffusivity estimates) to cope with the new emplacement mode so that a k-measurement (and heat flow value) with an error as low as 50-70% is likely (up from ~30% before modification).

3. Langseth seems to prefer HFE emplacement in a debris layer and suggests that a spot with a 3 meter layer can be found at most sites. This is probably operationally necessary with our present state of knowledge of the lunar surface and with the present HFE design. See 2.b.1 above.

4. Adequate effort is being made to involve the astronauts in the drill modifications to maximize the probability that the astronaut office will commit to the final task.

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